serve to fill up many a gap in the early history of the country. The main hindrances to progress are at present:—first, the exclusiveness of both Hindus and Mohammedans, who object to the examination of buildings which are still used for worship; secondly, the fact that many important ancient buildings are situated within the territories of native States, where it has up to the present been impossible to arrange satisfactory schemes for conservation and excavation. In spite of these drawbacks, archæological research in India has now been placed upon a sound footing, and in the immediate future a large amount of fresh material, in the shape of sculptures and inscriptions, will be at the disposal of students.

ON ICE AND ITS NATURAL HISTORY[1].

DURING the Antarctic cruise of the *Challenger* in the early part of the year 1874 I carefully examined the chemical and physical properties of sea ice. The melting temperature of the ice varied with the samples, but it was always below 0° C., and it was found impossible by any means to produce pure water by melting it. These two facts were for me convincing evidence, at that date, that the salt was present in the ice in the solid state, and that, consequently, the crystalline body, formed by freezing sea-water and similar saline solutions, was not pure ice.

About nine years later Dr. Otto Petterssen, having his attention directed in a similar way to the same subject, arrived at the same conclusion. His observations and their discussion are embodied in a remarkable paper on the properties of ice and water (Publications of the *Vega* Expedition, 1883). In the careful study which I made of this work the following passage arrested my attention:—"A thermometer immersed in a mixture of snow and sea water, which is constantly stirred, indicates −1°·8 C."

If this statement was exact, it was clear that the evidence furnished by the melting temperature of the sea ice was not entitled to the weight which I attached to it, and that the conclusion at which we had independently arrived was open to doubt. On repeating the experiment, I was able to confirm Petterssen's statement. I then proceeded to investigate the subject in detail. The principle which guided the investigation was the following:—if the crystalline body, which is formed when a non-saturated saline solution is partially frozen, is pure ice, then pure ice of independent origin, such as snow, must, when mixed with the same saline solution, and heat is supplied, melt at the same temperature when the concentration is the same.

This was found to be the case; and the result of the research was definitively to establish, on experimental evidence, the validity of the principle that, when a non-saturated saline solution is partially frozen, the crystals which are formed are pure ice; and, by consequence, that the salt from which it is, in practice, impossible to free them, belongs to the adhering brine.[2]

It was not until after this had been established, in 1887, that it became legitimate to say "the freezing point of *water* is lowered by the presence of salt dissolved in it," instead of saying "the freezing point of a *saline solution* is so much lower than that of pure water." The former of these statements expresses the fundamental principle of cryometric chemistry.

Shortly, *I define the freezing and melting temperature of a substance to be the temperature at which it as a solid passes into itself as a liquid, and as a liquid passes into itself as a solid.* In terms of this definition the freezing and melting temperature of the substance H_2O is 0° C. In order to represent the *temperature at which ice melts*, this definition requires a double qualification. At constant pressure the temperature at which ice melts depends on the nature of the medium in which it melts and if the nature of the medium be constant, the temperature at which ice melts depends on the pressure. Of the two modifying agencies, the influence of the medium preponderates in nature. Indeed, inasmuch as perfectly pure water is rarely, if ever, met with, it is probable that, *in nature, ice never melts and water never freezes exactly at* 0° C.

The principle that the temperature at which ice melts depends on the nature of the medium in which it melts is the key to the natural history of ice, and it forms the theme or text of this discourse. It at once brings into order the anomalies frequently observed in the experimental determination of many of the physical constants of ice, such as its coefficient of thermal expansion, its specific and its latent heat. When the ice or the water in which it is immersed contains any impurity, the temperature at which the ice begins to melt is below 0° C., and the substance under examination, which is taken for pure solid ice, is in reality a mixture of ice and impure water.

In discussing this subject, chloride of sodium is taken as the representative impurity, because it is the most widely disseminated ingredient of natural waters. It has also been more thoroughly studied than other salts in its behaviour to ice, water, and steam. In discussing the influence which this salt exercises over the apparent physical properties of ice a constant quantity of it is considered, and the quantity of ice on which it acts is varied. The constant quantity of the salt is 1·5105 grams, which contain 0·9167 gram of chlorine. The specific gravity of pure ice is taken as 0·9167 referred to that of water at the same temperature as unity.

It will be recognised that when 1000 c.c. of ice containing 1·5105 grams NaCl are melted, they furnish a water which contains chlorine in the proportion of 1 : 1000 by weight. The coefficient of cubic expansion by heat of pure ice is taken as 0·00016, and it is assumed to be constant at the temperatures under consideration. The volume occupied by the 1·5105 grams NaCl is disregarded. The cryohydric temperature of NaCl solution is taken as −21°·72 C., and its cryohydric concentration as 29·97 grams salt to 100 grams water.

Using these constants, we will apply the principle to the calculation of the apparent variations of volume of a block of ice the volume of which at 0° C. is 1000 c.c. It contains diffused through it 1·5105 grams NaCl, which we assume to be provisionally in the *inert* state, in which it is deprived of the power to induce the melting of ice at temperatures between 0° C. and −21°·72 C. Let the temperature of the block containing the inert NaCl be reduced to −23° C.; its volume will be reduced to 996·320 c.c., and as the temperature is below the cryohydric temperature, the salt is by nature inert; at such temperatures ice and common salt are indifferent to each other. Let the temperature of the block of ice be now raised to −22°; the salt remains inert, and the volume of the ice increases to 996·48 c.c. If the temperature is further increased to −21°·721, the NaCl will still remain inert, and the volume of the ice will become 996·525 c.c.

If the heating is continued the temperature rises exactly to the cryohydric point, −21°·72, at which temperature the indifference of chloride of sodium to ice ceases, and induced melting at that temperature takes place. It will then be observed that the temperature remains constant for a time, while the volume of the block diminishes. When the temperature begins to rise, the volume of ice melted will be 5·498 c.c. As this produces 5·040 c.c. water, the diminution of volume is 0·458 c.c., and the apparent volume of the block is 996·067 c.c.

Let us now go back to the initial state, in which we have the block of 1000 c.c. ice, containing 1·5105 grams inert NaCl diffused through it, at the temperature 0° C. Let the temperature be reduced to −21° C., the ice remaining inert. The volume of the ice will then be 996·64 c.c. Let the NaCl recover its activity, it will melt 5·629 c.c. ice, producing 5·160 c.c. water under a contraction of 0·469 c.c., so that the apparent volume of the ice at −21° C. is 996·64−0·469=996·171 c.c. Proceeding by steps in this way, we obtain, for different temperatures *t*, the volume of the ice containing inert salt V, the volume of ice melted by the salt when its activity is restored v, the contraction so produced c, and the resulting apparent volume of the ice $U = V - c$. The values of v are derived from the observed freezing points of specified NaCl solutions. The results calculated for certain values of t are given in Table I. :—

---

[1] Abridged from a discourse delivered at the Royal Institution on Friday evening, May 8, by J. Y. Buchanan, F.R.S.

[2] The results of the research which I began in the year 1886 were communicated to the Royal Society of Edinburgh in a paper "On Ice and Brines," which was read on March 21, 1887, and was published in the Proceedings of the Society, vol. xiv., pp. 129–149. A full account of it was also published in NATURE, 1887, vol. xxxv., p. 608, and vol. xxxvi., p. 9. The whole subject of the influence of dissolved salt on the state of aggregation of the substance H_2O at temperatures below its normal freezing and melting point and above its normal boiling and condensing point was passed in review in my chemical and physical notes in the "Antarctic Manual," 1901, pp. 73–108.

TABLE I.

t	V	v	c	U	t	V	v	c	U
° C.	c.c.	c.c.	c.c.	c.c.	° C.	c.c.	c.c.	c.c.	c.c.
−23	996·320	0		996·320	−8	998·720	12·531	1·044	997·676
−22	996·480	0		996·480	−7·2	998·848	13·884	1·157	997·691
−21·721	996·520	0		996·520	−7·0	998·880	14·195	1·183	997·697
−21·72	996·520	5·498	0·458	996·067	−6·8	998·912	14·628	1·219	997·693
−21	996·640	5·629	0·469	996·171	−1·0	999·840	98·350	8·196	991·644
−20	996·800	5·825	0·485	996·315	−0·1	999·984	998·35	85·196	916·788

If we study this table we see that *between the temperatures −23° and 0° the coefficient of apparent dilatation of the ice changes sign three times—namely, twice at the cryohydric temperature, and once at a higher temperature.* Between −23° and the cryohydric point −21·°72 the expansion is uniform, the coefficient being 0·00016. At the cryohydric point the addition of heat produces contraction without change of temperature; the coefficient, therefore, is $-x$. Above the cryohydric temperature the volume increases with the temperature, but at a gradually diminishing rate, until at −7°·0 the increase of volume due to simple expansion of the ice is exactly balanced by the contraction due to induced melting. At this temperature the coefficient of expansion changes sign, and between −7°·0 and −0°·1, at which the ice has practically all melted, the coefficient of expansion is negative.

If the block of ice contained salt in the proportion 29·97 grams NaCl to 100 grams ice, it would expand uniformly on being warmed from −23° to −21°·72, and would then melt completely at that temperature. In the same way, if it contained no salt or impurity whatever, it would, on being warmed, expand uniformly, while its temperature rose, until, at 0° C., it would melt completely. If the ice contains salt in a less proportion than 1·7164 : 100 by weight, then we witness the three changes of sign in the coefficient of dilatation when the temperature rises from below the cryohydric point to the temperature at which the ice is finally liquefied. When the block contains, per 100 parts by weight of ice, less than 29·97 and more than 1·7164 parts of NaCl, the coefficient of apparent expansion is negative at all temperatures above −21°·72.

In Table II we have the upper critical temperature (τ) at which the coefficient of apparent dilatation changes sign for blocks of ice having volumes ranging from 100 cubic centimetres to 100 cubic metres, each containing 1·5105 grams NaCl. Under V_0 we have the initial volume of the block of ice supposed pure and solid at 0° C., and under v the volume of ice which can be melted under the inducing influence of 1·5105 grams of chloride of sodium at the critical temperature τ, at which the apparent coefficient of cubic expansion of the ice is equal to 0.

TABLE II.

V_0	v	τ	V_0	v	τ	V_0	v	τ
c.c.	c.c.	° C.	c.c.	c.c.	° C.	c.m.	c.c.	° C.
100	5·73	−20·5	1000	14·20	−7·0	0·01	41·83	−2·3
200	6·74	−16·6	2000	20·00	−4·9	0·1	136·3	−0·725
400	9·85	−10·75	4000	27·80	−3·5	1·0	438	−0·2275
600	11·75	−8·65	6000	32·24	−2·95	10·0	1377	−0·0725
800	12·85	−7·8	8000	37·57	−2·55	100·0	4306	−0·02275

A block of 100 c.c. of ice, which contains 1·5105 grams of NaCl diffused through it, furnishes on being melted 91·67 c.c. of water, which contain 0·9167 gram of chlorine, dissolved in it as chloride of sodium. This water contains chlorine in the proportion 1 gram to 100 grams of water, and represents a concentration about one-half that of average sea water. When the volume of ice, V_0, is 1 cubic metre, the water produced by its melting contains chlorine in the proportion of one part to one million parts of water by weight.

Waters which contain dissolved matter equivalent to no more than 1 gram of chlorine in 10,000 grams of water are in the category of ordinary fresh waters, and we see that the critical temperature of ice which furnishes such water lies as low as −2°·3. When the dissolved matter is equivalent only to 1 gram of chlorine in 100,000 grams of water, the critical temperature is −0°·725. The other waters are in the category of distilled waters, and it is doubtful if, by any chemical means whatever, we could determine as little dissolved matter as 1 gram chlorine in one ton of water; yet the critical temperature of such ice lies nearly a quarter of a degree below the melting temperature of pure ice. The critical temperature of expansion of ice affords a means of detecting impurity equivalent to quantities of chlorine as small as one gram in ten tons, and even one gram in one hundred tons of water.

Influence of Impurity on the Apparent Latent Heat of Ice.

This is illustrated by the numbers in Table I. Thus, at −1° C., the apparent volume of the block of ice is 991·644 c.c., and it is made up of 901·49 c.c. ice and 90·154 c.c. water. When this is warmed to −0°·1, we may take it that the whole of the ice is melted. Taking the latent heat per unit volume of ice as 66·5 at −0°·1, and its specific heat per unit volume as 0·45, the heat required to raise the ice from −1° to −0°·1 is 365·1 gram-degrees (gr.°); that required to raise the temperature of the water by the same amount is 81·14 gr.°, and the heat required to melt the ice at −0°·1 is 59949 gr.°, the total heat used being 60395·2 gr.°. If we ignore the possibility of partial melting, and assume that we have 999·84 c.c. solid ice at −1°, and that its temperature is raised to 0°, at which temperature it melts, we have the following expenditure of heat:—for rise of temperature 449·9 gr.°, and for melting 66489·3 gr.°, making together 66939·2 gr.°, as against 60391·5 gr.°. If from 60395·2 gr.° we deduct the heat calculated for warming the ice in the second case, 449·9 gr.°, we obtain 59945·4 gr.° as the heat required to melt 1000 c.c., or 916·7 grams, of ice at 0°, whence the latent heat would be, per unit volume, 59·94, and per unit weight 65·39.

This example illustrates also the effect of impurity on the apparent specific heat of ice.

The nature of the medium is responsible in the case of sea ice for depressions of freezing and melting temperatures of thirty, forty, or even more degrees of Celsius's thermometer, while the greatest pressure to which freshwater ice is exposed in nature cannot produce an alteration of freezing and melting point amounting to much more than one degree.

If we pick up a piece of ice floating in the Polar Sea we know that it will prove to be very far from homogeneous. It may have a foundation of genuine primary sea ice, but the ice forming the superstructure is sure to consist of snow, frozen spray, and very likely fragments of land ice, all cemented together into a species of conglomerate. When this is exposed to warmth it begins to melt at a temperature which may be one or two degrees below the melting point of pure ice, and the liquid so furnished is salt water. The further melting takes place in ascending order of temperature, the salt ice of low melting point disappearing first, and the purer ice melting later. We thus see how ice can be cemented by ice, just as metallic objects may be united by solder. In both cases the substance of the binding material differs from that of the objects united, chiefly in being more easily fusible.

If we have a number of cubes of pure ice which fit each other exactly, and if, after being moistened with salt water, they are exposed to frost, they will solidify to a single block. If this be exposed to the sun the cementing salt ice will melt first, and, when it ceases to bind, the constituent cubes of pure ice will fall asunder, having themselves suffered practically no diminution due to melting.

Now this is precisely what happens when a block of sound glacier ice is exposed to the rays of the sun for a short time, and it is one of the most striking and instructive experiments that can be made. Under the influence of the sun's rays, the binding material melts first, the continuity of the block is destroyed, the individual grains become loose and rattle if the block be shaken, and, finally, they fall into a heap. A block of glacier ice is a geometrical curiosity. It consists of a number of solid bodies of different sizes and of quite irregular shapes, yet they fit into each other as exactly and fill space as completely as could the cubes above referred to.

Particulars with regard to the size of the grain of the Aletsch and the Bossons glaciers will be found in an article in NATURE (1901), vol. lxiv., p. 399.

Disarticulation of the Grains of the Glacier by Solar Radiation.

In the Mergelin See, glacier ice can be studied in a way that is possible in no other place. The fragments of the Aletsch Glacier which float in it are veritable icebergs. In the middle of summer they are exposed to a very powerful sun, and the weathering and disintegration, as well as the melting, proceed at a very rapid rate.

The action of the sun's rays on glacier ice is two-fold; it disarticulates the ice into its constituent grains, and it splits the individual grain up into laminæ perpendicular to the principal axis of the crystal, and bounded by the planes of fusion described by Tyndall. These planes are the distinguishing characteristic of the individual ice-grain.

Under the influence of radiant heat an ice-grain begins to melt at the surfaces which separate these laminæ, and the process of disintegration and decay is directed by their plane. On the other hand, an ice-grain, floating in water and losing heat, generates ice laminæ which are directed by the same planes, which form the continuation of the corresponding laminæ of the parent crystal. As the grains in a block of glacier ice are distributed quite irregularly, the water-line of a floating block necessarily cuts a great number of grains, all of which are oriented differently. The ice which is formed during the night along this line is oriented crystallographically by the grain with which it is in contact, and from which it appears to spring in continuation of its crystalline laminæ. This produces a remarkable pattern of lines on the surface of the lake ice contiguous to a block of glacier ice.

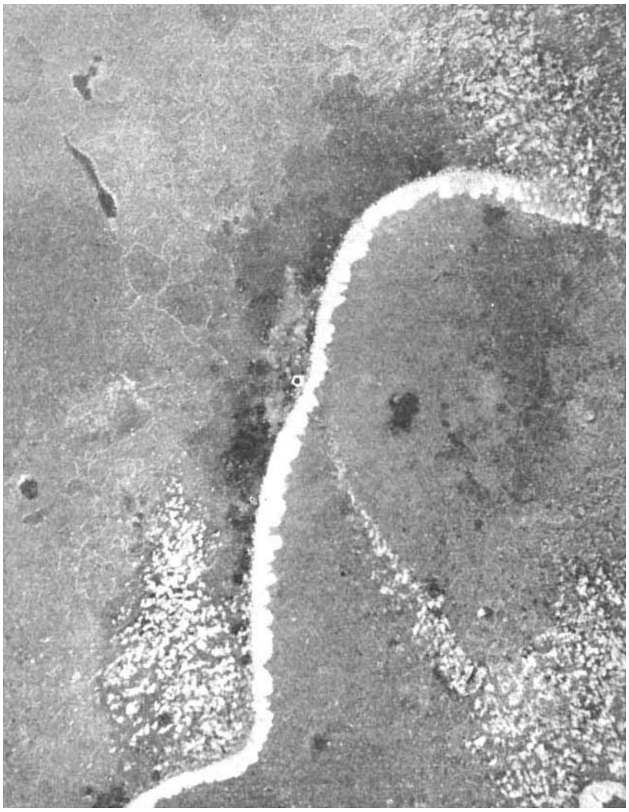
Tyndall has described and figured the minute features of the disintegration of the crystal under the absorption of radiant heat. Similar and complementary features are observed when ice is generated from an existing crystal under the dissipation of heat. To do justice to them, however, would require the services of a skilful, patient, and resourceful artist.

The disarticulating and analysing action of the sun's rays is not accomplished without selection and the expenditure of energy. Accordingly we observe that one grain protects another. The disarticulation into separate grains, although very thorough near the surface of a glacier, does not penetrate far. A stroke or two with an ice-axe reveals the fresh blue ice. In the case of an iceberg, whether floating in a lake or in the ocean, only the grains that are exposed to the sky and above water are disarticulated, and prolonged exposure of this kind reduces a grain to the last stage of dilapidation. The grains beneath the surface, *whether of ice or water*, are almost completely unattacked.

The importance of direct skylight for the disarticulation of glacier ice into its constituent grains is very well seen in the artificial grottos which are maintained at easily accessible parts of most popular glaciers. The thickness of the layer of completely disarticulated ice is so small that it is hardly noticed, and the whole grotto appears to be cut out of pure blue ice. If the observer, on penetrating for a few paces, turns round and looks outwards, he sees the surface of the ice-walls of the grotto etched with strange line figures. These are most strongly marked near the opening, and they extend as far as direct skylight strikes the ice. The lines so developed are formed by the intersection of the surface of the ice-wall of the cave with the separating surfaces of contiguous ice-grains. The picture thus presented is one of very great interest.

Delineation of the Grain by Hoar-frost.

After the autumnal equinox very little melting of ice takes place, and by the end of October it has, as a rule, ceased entirely. The etched figures on the walls of the entrance of the grotto, which were developed by solar radiation during summer, disappear quickly with the arrival of winter; but the winter brings with it another means of delineation of the grain which does not depend on solar radiation. Even at the lowest of winter temperatures the atmosphere contains vapour of water, which it is prepared to relinquish under the same conditions as those under which dew is formed in summer. In the Alpine winter, however, it is deposited, not as dew, but as rime, that is, not as water, but as ice. It is well known that very fine etching on a polished surface, which can with difficulty be seen without assistance, at once becomes visible if the surface be breathed on. In winter the walls and roof of the grotto are cold, dry, smooth, and polished like glass. The winter air entering from without and circulating in the grotto *breathes* on the polished surface of ice and develops the figure of the ice by the rime which is deposited on it. As rime always settles by preference on sharp edges, it seeks out the lines of separation between the grains and settles on them, showing the whole granular structure. In January, 1907, there was a wonderful exhibition of this natural damascening on the roof of the cave of the Morteratsch glacier; in January, 1908, however, it was quite inferior, and would not have struck the eye. The illustration represents a portion of the roof of the cave which I photographed in January, 1907. As the roof is not flat, but made up of shell-like cavities worn by the hot air in summer, the delineation of the grain is sharp in some parts of the photograph and faint in others.



Grain of the glacier on the roof of the grotto in the Morteratsch Glacier elineated by hoar-frost, January, 1907.

A precisely similar phenomenon was observed in 1886 by Prof. Forel in the remarkable natural grotto of the Arolla glacier, of which he has given so fascinating a description in the *Archives des Sciences physiques et naturelles, Genève,* 1887, xvii., p. 498. The delineation of the etched figures by rime was observed by him in the month of July in a remote and secluded chamber nearly 250 metres from the entrance of the grotto. In artificial grottos like that of the Morteratsch glacier, in which the air circulates freely, the hoar-frost disappears very quickly with the end of winter.

The Grain of Lake Ice.

It is not glacier ice alone which suffers disintegration when exposed to a powerful sun. Lake ice behaves in a similar way. Beautiful examples of this can be seen in Alpine seas every winter. During the harvesting of the ice from the lake, the blocks often lie for a day or more before they are carted away to the ice-houses. Occasionally some of them get overlooked and remain for many days exposed to the powerful sun of February, while maintaining the low temperature of the air usual in that month. No melting takes place, but after even a few hours' exposure to the sun the block shows the figure of its grain in development. It is being etched by the sun's radiation.

The grain of lake ice has a very different appearance from that of glacier ice, but both are individual crystals. The difference in their appearance is to be traced to the difference of treatment which they have received during their existence. The glacier grains have been practically rolling over each other during their descent, while those of the lake have established themselves at right angles to the surface of the water, and have remained there. So long as the ice is increasing in thickness, the temperature of its upper surface is very low. It is perfectly transparent, and its surface is smooth, dry, and polished like glass, and it shows no trace of crystalline figure. When the ice is undisturbed this develops itself only at the end of the season when the thaw sets in. Then the whole ice-sheet rises to its melting temperature, and is at the same time exposed to the direct radiation of the sun. This produces disarticulation of the ice into groups of vertical prisms which are then floating independently; they are kept together only by crowding. Ice in this state is said to be rotten; and it will be recognised that, however thick the ice-sheet may be, when it gets into this condition it is dangerous. In the neighbourhood of the outflow the crowding is relieved, the disarticulated groups become disengaged, the smaller groups and individual prisms are able to assume their attitude of stability and to float on their sides. All then drift towards the outlet. The ice "breaks up," and the lake is cleared in an astonishingly short time.

If it were not for the law that even impure water in freezing always forms pure ice, the impurity remaining in the liquid and generally entangled in the interstices of the grains, and that the pure ice which is in contact with this impure liquid melts at a lower temperature than that which is in contact with nothing but the water formed by its own melting, the ice-covering of a lake would be a continuous sheet offering no points of weakness, and it would have to melt as a whole. It is doubtful if lakes such as those, met with in the Upper Engadine, would get rid of their ice-covering at all. On the Silser See the ice is usually more than 60 centimetres thick when the thaw sets in, but when once the ice begins to break up the lake is cleared in a day. Sixty centimetres of ice would take a long time to disappear on the basis of surface melting alone.

While the winter lasts, the ice on the lake shows no crystalline structure. This develops only after removal from the water and exposure to the sun. The ice then splits up into prisms in a vertical plane. These are at first of irregular section, and as sun-weathering proceeds the thicker prisms split up into thinner. When a block has lain exposed to the February sun and cold it may fall to pieces, each piece being a long, thin, triangular prism, with some resemblance to a razor-blade. When the ice is cold and dry the outlines of the grains are lines; when the ice has a temperature of 0° C. it melts preferably round the grain, forming troughs in which the water collects, and the aspect is that of a dark polygon surrounded by light-coloured canals. The columnar grains have their striation like those of the glacier. In one piece, which was much weathered, I counted twenty-four such grains in an area of 9 square centimetres. In a slab which had not been lying long I counted twenty-three grains in an area of 150 square centimetres, giving an average area of 6·5 square centimetres per grain; the largest had an area of 12 square centimetres. In another slab there was a very large grain which measured 7 centimetres in one direction and 4 centimetres at right angles to it. In a slab in which the sun-weathering had proceeded very far I counted 113 grains in a disc of 5 centimetres radius, which gives 0·69 centimetre as the average area per grain.

In the absence of actual experience, one is apt to expect a slab of lake ice, when subjected to sun-weathering, to be disarticulated into hexagonal columns; but this expectation is quite gratuitous. Ice may crystallise in a form bounded by plane faces, according to the laws of its crystallographic system, if it has the freedom which it possesses when crystallising out of an independent medium such as a saline solution or air. But the foreign matter dissolved in fresh water is present in so small quantity that what we have before us is the solidification rather than the crystallisation of ice, and each column as it tries to develop itself is interfered with by its neighbour, and the resulting slab of ice is made up of elementary prisms crowded together, but preserving parallelism of crystallographic axis.

The second part of the discourse dealt with the part played by glaciers and rivers in modifying the features of the surface of the earth, but it cannot be usefully condensed so as to be included in this communication.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

The University of Jena, at its recent jubilee, conferred the degree of M.D., *honoris causa*, on Sir William Ramsay, K.C.B., F.R.S.

Mr. W. J. Horne, lecturer in physics at the South African College, Cape Town, has been appointed to the inspectorate of the Transvaal Department of Public Education as organiser for technical education.

Upon the authority of the *Cologne Gazette*, a Reuter correspondent states that the question of the admission of women to university study in Germany has been settled. Women who are subjects of the German Empire will be admitted on the same footing as men, but women of other countries will require the permission of the Minister of Public Instruction for matriculation.

A paper on the educational aspect of domestic subjects was read recently by Prof. A. Smithells at Bradford, the occasion being the fourth annual meeting of the Northern Union of Domestic Economy Associations. A verbatim report appears in the first August number of *Education*, and we learn therefrom that Prof. Smithells considers that the increased attention being paid to the teaching of domestic subjects is very gratifying. He wishes to bring such subjects within the purview of universities, as it is desirable to connect every branch of education with what should be the most abundant and vivifying springs of knowledge. The introduction of domestic subjects into the normal educational curriculum for girls would add a much wanted ingredient, as in the household arts we have a direct educational instrument for conferring upon girls the very great gift of manipulative skill, and of doing it by teaching the very work that will lie nearest to them in their normal daily life when they have left school. Domestic subjects include much that affects the cultivation of the moral and æsthetic side of human nature, and a good teacher will make them mentally stimulating.

The *Revue scientifique* for August 8 reproduces the address given by Prof. Paul Appell, the president of the French Association for the Advancement of Science, at the meeting at Clermont-Ferrand on August 3. As we mentioned in our issue of August 13, the address deals with the teaching of science and the formation of the scientific